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ON THE STRUCTURE OF THE PISTILS OF
SOME GRASSES

BY ELDA REMA WALKER

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II.—On the Structure of the Pistils of Some Grasses

BY ELDA REMA WALKER

The purpose of this investigation has been to determine to what extent there is evidence of a third carpel in the pistils of grasses.

The study has been carried on by means of cross and longitudinal sections, cut in different planes, as well as by a study of the external appearance of the pistils.¹ The following are the results obtained:

*Tribe Festuceae*²

The Festuceae show two distinct types of pistil and almost all grades between these.

The first type is shown most plainly in *Bromus*. *Bromus unioloides* may be taken as an example. Here the pistil is small at the base and increases in size rapidly for about a third of its length, then it constricts abruptly. From this point it expands into three parts. One of these extends up into a broad, slightly flattened and somewhat irregular lobe which is as large as, or even larger than, all the rest of the pistil. This forms the dorsal³ side of the top of the pistil. Each of the other two parts forms

¹Most of the material was killed in Flemming's solution and preserved in 65 per cent alcohol. Some specimens were killed with equal success in a solution consisting of one part acetic acid and two parts 95 per cent alcohol. Good results were also obtained from material preserved in 4 per cent formalin. The specimens were run from 65 per cent alcohol to pure Bergamot oil in nine hours. It was then left over night, and imbedding was completed nine hours later. By this process entire flowers, as well as single pistils, could be cut perfectly.

²The sequence of tribes used in this discussion is that proposed by Professor Charles E. Bessey.

³Dorsal is used to designate the side of the pistil next to the palet, and ventral that next to the lemma.

a small lobe, ventral to this, and extending upward and laterally to form the style-branches. This causes the style-branches to seem to arise from the side of the ovary. The pistil is densely covered with hairs. The styles branch above into feathered stigmata (pl. I, fig. 1). Three fibrovascular bundles arise from the base of the pistil and extend upward. Of these the middle, or dorsal, one is much the largest and bears the ovule, which is attached to the ovary nearly its entire length. It is, however, somewhat more free at the base, making it slightly pendulous. At the top of the cavity this bundle turns toward the center and divides into three parts. One of these extends upward into the large dorsal lobe of the pistil; the others turn to the side, and each fuses with one of the small lateral bundles which pass up the sides of the pistil and extends directly into its style-branch. On the anterior side of the pistil is a small fibrovascular bundle which is somewhat irregular in its extent. It is a descending branch of the dorsal bundle and extends down about half way from the top of the ovary (pls. I, II, figs. 2-27). In sections of very young pistils the development of these three lobes is evident. Two short style-branches are present, each with its fibrovascular bundle extending from the base of the pistil. At the dorsal side arises a short, thick lobe which extends between the style-branches, bears the ovule, and has its own fibrovascular bundle. The pistil has not yet closed in the specimens in hand, and no branches are present extending from the dorsal bundle to the styles (pl. II, figs. 28-30). The branches passing from this dorsal bundle to join the lateral bundles must be a later development which forms after the carpels have united.

Bromus secalinus, *B. racemosus*, and *B. brizaeformis* have the same structure but vary slightly in the relative size and shape of the pistil lobes. In *B. secalinus* the dorsal lobe is more regular in shape. The two anterior lobes are very distinct and the styles arise from their dorsal surface. Aside from such minor differences all of the Bromi studied were alike.¹

¹Baillon (Histoire des Plantes, Monographie des Graminées XII, 2, Paris, 1893, p. 142) describes and figures the same structure in *Bromus mollis*.

The pistil of *Festuca elatior* is so similar to that of *Bromus* that a separate description is needless. The dorsal lobe is not as large as in *Bromus*, otherwise the external appearance is the same. The fibrovascular system also agrees with the foregoing, except that the lateral bundles are very small.

In *Festuca rubra* the style-branches are terminal and the three-lobed appearance is nearly lost. There is, however, a slight enlargement on the dorsal side of the pistil. This corresponds to the large lobe of *Bromus*, and into it extends the dorsal bundle, which, as before, bears the ovule attached nearly its entire length. This bundle, however, only extends to the top of the ovary cavity and turns over it slightly. It has no lateral branches going to the style-branches. The lateral bundles extend from the base of the pistil up each side and pass, one into each style-branch. We have here, then, the same general structure as in *Bromus* except that the bundles are distinct through their entire extent and the dorsal lobe is almost lost (pl. II, figs. 31-42).

Festuca octoflora has the same type of pistil as *F. rubra*, but the dorsal lobe is slightly more evident.

Dactylis glomerata has a pistil almost exactly like that of *Festuca rubra* both in external and internal structure. The small size makes it difficult to make out the fibrovascular system in cross-section, but in longitudinal section and in mounts of the entire pistil the three bundles are distinctly seen, one on each side extending upward into the style-branches, and the dorsal one bearing the ovule.

The pistil of *Poa pratensis* has the style-branches terminal also. Here almost all trace of the dorsal lobe is lost, and the pistil terminates in two style-branches. There is, however, the third fibrovascular bundle which bears the ovule as before. This bundle is large and above the ovary turns to the center of the pistil; here it divides, and one-half goes to each style-branch, at the base of which it unites with the lateral bundles, which, in most pistils of this form, are the only ones entering the style-branches. This, then, is a type intermediate between the *Bromus* pistil and those having the typical terminal style-branches, and with the bundles entirely separate, as in *Festuca rubra*.

The extreme of the second type of pistil found in the Festuceae is that of *Distichlis spicata*. Here the pistil has terminal style-branches, but the ovary is somewhat elongated and terminates in a thick style which divides into two branches bearing the stigmata. The ovary cavity occupies only a small space at the base of the pistil. The ovule is attached a little less than half-way up on one side and the placenta extends only about one-third the length of the cavity, giving the ovule the appearance of having a very short funiculus. The three fibrovascular bundles arise as usual and extend upward. The dorsal one is large to the point of attachment of the ovule; it then becomes suddenly smaller, turns over the ovary cavity, and runs upward through the middle of the style. The smaller lateral bundles are at each side, and the three run almost parallel to near the point of branching of the style. Here they come very close together and almost lose their identity; then the central one disappears and each lateral bundle extends into one of the style-branches (pl. III, figs. 43-55).

Tribe Hordeae

The Hordeae show a rather uniform structure of pistil. All are of the general *Bromus* type with the lobes much reduced and the style-branches quite erect and arising between the larger dorsal lobe and the smaller ventral ones.

Lolium perenne shows an interesting modification of the *Bromus* form. The pistil is very short and thick and shows three distinct lobes extending to its base. The dorsal one is large and flat, narrow at the base, and widening toward the top where it ends in a broad, rounded lobe. This extends the full width of the pistil and is the longest lobe. The other two lobes form the other half of the pistil, and together are wider at the base than the dorsal lobe, but at the top the two halves of the pistil are about equal in width. Each of the two smaller lobes is quite distinct and rounded, and from the back of each a style-branch arises between its lobe and the dorsal one (pl. III, figs. 56, 57). In section the structure much resembles that of *Bromus*. The lateral fibrovascular bundles are very small and extend into the

style-branches. The dorsal bundle is large and bears the ovule. Above the ovary it divides and part goes to each style-branch, but instead of uniting with the lateral bundles, as in *Bromus*, the two run through the styles parallel and distinct.

Hordeum pusillum and *H. jubatum* have pistils much like that of *Bromus*. The three lobes, however, are not so distinct nor as large, and the style-branches are much thicker and more erect. The ovule occupies only the lower half of the ovary. The fibrovascular bundles are quite distinct, but the dorsal one sends small branches to the styles. *Agropyrum repens* and *A. occidentale* have the same type of pistil. In the earlier stages it has terminal style-branches, and the three fibrovascular bundles are distinct. Later the dorsal side of the pistil enlarges upward and forms a lobe much like that in *Bromus* but much smaller. On the other side two small lobes appear and from these the style-branches extend. Thus the mature pistil has much the form of that of *Bromus*, but the fibrovascular bundles remain distinct. The style-branches are large and erect, however, so they appear to be terminal, but close examination shows that the dorsal side is prolonged a little above their base.

The pistil of *Triticum sativum* also has the appearance of one with two terminal style-branches, but the ovary has four longitudinal depressions extending from its base to near its top, where they disappear. From the top of the lateral depression arise the style-branches. Above the dorsal one rises a small lobe, and above the ventral depression in some cases is a still smaller enlargement. In section, the three fibrovascular bundles are found as in the other grasses. These correspond with three of the longitudinal depressions (the two lateral and the dorsal). The dorsal one bears the ovule, the other two extend into the style-branches. At the anterior side of the pistil is the fourth depression, and corresponding with this is a mass of tissue which stains like a fibrovascular bundle but otherwise has the appearance of a suture. The ovule is attached at the side of the ovary and is somewhat pendulous. The pistil has thus a structure about half-way between *Bromus* and *Distichlis*. The fibrovascular structure is like that of the latter, but the exterior has more of the lobed

structure of *Bromus* excepting the terminal style-branches (pls. III and IV, figs. 58-72).

The pistil of *Secale cereale* is so much like that described in *Festuca rubra* that it need not be repeated here. The two are exactly alike in external form and in structure, except that the dorsal lobe is a little more prominent in *Secale*.

The pistil of *Elymus glaucus* differs from that of *Secale* only in that the dorsal lobe is more prominent.

Tribe Chlorideae

Of the Chlorideae only two genera were observed, *Bulbilis dactyloides* and *Beckmannia erucaeformis*. The pistils of the two are exactly alike. They are of the type with terminal style-branches. The ovary is rounded and tapers abruptly at the top, where it gives rise to two style-branches. The fibrovascular system is very clearly defined. The lateral bundles are large and distinct, extending from the base of the pistil up the side of the ovary into the style-branches. The dorsal bundle is large but short, extending only to the top of the ovule which is attached near the base of the ovary.

Tribe Aveneae

Avena sativa may be taken as representative of the pistil found in the Aveneae. It has terminal style-branches arising from the top of a short, thick ovary which is narrowed at the base. The entire pistil is densely hairy. The fibrovascular system is like that of *Bromus*. The dorsal, ovule-bearing bundle divides above the ovary into two large branches. One goes to each style-branch, but remains distinct from the smaller lateral bundles almost to the end of the style-branches. The ovule has the usual lateral placenta near the top of the dorsal side of the ovary.

Deschampsia elongata differs from *Avena* only in that the dorsal lobe is distinct although small.

In *Holcus lanatus* the fibrovascular bundles are less distinct and the ovule is attached higher. Otherwise it is like the two preceding.

Arrhenatherum elatius is like *Avena* in pistil structure, except that the dorsal bundle ends above the ovule and the lateral bundles alone go to the style-branches.

Tribe Agrostideae

The Agrostideae observed all have terminal branches and have the three fibrovascular bundles entirely separate, the dorsal one bearing the ovule and the lateral ones running into the style-branches.

Phleum pratense and *Alopecurus geniculatus* are so small that it is difficult to follow the bundles, but faint indications of the three bundles were observed agreeing with the other species of the tribe.

Stipa spartea has a pistil which is much elongated, and which divides directly into two thick style-branches, densely feathered at the upper end. The ovary occupies only the lower third of the pistil. The line of union of the two style-branches shows as a suture down the center of the pistil to the ovary. The dorsal, ovule-bearing fibrovascular bundle is large, but extends only a very little above the ovule. The two lateral bundles are very well marked and extend directly into the style-branches. The structure which, in all the other specimens studied, has appeared as a ventral suture, or a dorsiventral extension of the fibrovascular system, here appears as a distinct fibrovascular bundle arising from the base of the pistil, as do other bundles, and extends up to within a short distance of the branching of the style. It is, however, the same structure showing in the more marked manner. The ovule has the usual dorsal placenta (pl. IV, figs. 73-90).

Tribe Phalarideae

Only one species of the Phalarideae was studied. This was *Phalaris arundinacea*. It has two style-branches arising from the summit of the ovary. The fibrovascular system is poorly defined, but shows faintly the three bundles, the dorsal one bearing the ovule and the two lateral ones passing to the style-branches, as is common in this type of pistil.

Tribe Oryzaceae

Of the Oryzaceae only *Oryza sativa* was studied. This has a pistil with a short style which divides into the style-branches. Usually these are two in number, but rarely three are found, and quite often two and a rudiment are present. This rudimentary style-branch appears as a short lobe about the size of the base of the normal style-branches, and extends up a short distance (pl. IV, fig. 91). In section the usual fibrovascular structure is found (pl. V, figs. 93-108). The lateral bundles are distinct and extend into the two style-branches while the dorsal (larger) bundle bears the ovule, which hangs from the side of the ovary wall (pl. V, fig. 97). In the normal pistil this bundle extends upward to near the point of branching of the style, but in the pistils having the rudimentary third branch the bundle is prolonged into it. The pistil having three complete style-branches (pl. V, fig. 92) were all found in dried material and could not be sectioned, but this third branch must represent the full development of the structure seen in the rudimentary branch. It is evident that the rudimentary style-branch is that of the third carpel, which is dorsal and bears the ovule.

Tribe Paniceae

The Paniceae all have two style-branches arising directly from the top of the ovary, and a rudimentary third branch on the dorsal side.¹ This varies in its prominence and extends to some extent between the two style-branches and is concave on the inner side. All have the three fibrovascular bundles distinct. The lateral ones extend into the style-branches and the dorsal one bears the ovule and extends upward into the dorsal lobe, or rudimentary style-branch.

¹Baillon (Monographie des Graminées, Hist. des Plantes, XII, 2, Paris, 1893, p. 172) describes the pistils of the Paniceae as follows: "Ces branches sont excentriques, et, dans leur intervalle, beaucoup d'espèces présentent une troisième lobe saillant, plus ou moins prononcé, en général très petit, concave en dedans et à la base duquel se voit plus ou moins distinctement l'acropyle."

In *Chaetochloa glauca* and *C. viridis* the dorsal lobe is about the size of the base of one of the style-branches, but is rounded on top and about as long as broad ($15\ \mu$): The dorsal bundle is much larger than the lateral ones as far as the top of the ovule where it decreases in size, and the much smaller end extends to the dorsal lobe (pl. V, figs. 109-115).

Panicum scribnerianum and *P. proliferum* have the same structure as *Chaetochloa*, but the dorsal lobe is more prominent, being about twice as long ($33\ \mu$) (pl. V, figs. 116-117).

Tribe Andropogoneae

Andropogon sorghum was the only one of the Andropogoneae noted. Here the pistil has two style-branches arising directly from the top of the ovary. In one case a very small dorsal lobe was found, but it is not common. There is a distinct fibrovascular bundle extending into each style-branch where it spreads out, having the appearance of two bundles. The dorsal ovule-bearing bundle extends only to the upper part of the attachment of the ovule. This bundle breaks up into six, or sometimes eight, parts and spreads over nearly a third of the circumference of the ovary, but unites at its upper part into one bundle again. The ovule is attached to this wide bundle near the base of the ovary and is erect (pl. V, figs. 118, 119).

Tribe Maydeae

Of the Maydeae, *Zea mays* and *Enchlaena luxurians* were observed.

Zea mays has a pistil bearing the long style (silk) which branches at its extreme tip. At the top of the ovary is a small projection or lobe on the dorsal side.¹ The style has two fibrovascular bundles arising in the usual manner from the base of the ovary. One extends into each of the small branches at the

¹ Poindexter (*The Development of the Spikelet and Grain of Corn*. Ohio Naturalist III, 1903, p. 5) describes this structure and also the development of the pistil, and illustrates it with diagrams.

tip of the style. The attachment of the ovule is almost basal and but slightly lateral, and below the dorsal elevation mentioned above. The dorsal ovule-bearing bundle branches into several parts as described for *Andropogon*. It extends very little above the attachment of the ovule. In development, the pistil arises as two elevations, one of which soon elongates into the style; the other bears the ovule and forms the elevation at the top of the mature ovary (pl. V, figs. 120, 121).

The pistil of *Euchlaena luxurians* tapers into a long style which has a longitudinal groove, as does *Zea*, and at the tip has two short branches. The ovule is attached near the base of the ovary and is on the wide dorsal fibrovascular bundle which branches into many parts and extends over a third of the circumference of the ovary. The style-bundles are two in number, as usual, and extend parallel throughout the long style. A third bundle is present in the lower part of the style which is a faint continuation of the dorsal bundle. This gives the base of the style a three-lobed appearance, and this third lobe ends in an elevation corresponding to the dorsal lobe of *Zea mays*.

DISCUSSION

From the above descriptions it is evident that in all of the grasses examined each pistil contains three fibrovascular bundles, one extending to each style-branch and a third (dorsal) bearing the ovule and extending into the dorsal lobe, or rudimentary style-branch, when one is present. Since in forms like *Oryza*, pistils are found with two style-branches, others with two and a rudiment, and still others with three distinct and complete style-branches, and since it is the dorsal, ovule-bearing bundle which is extended into this rudimentary style-branch, it would seem that the typical *Oryza* pistil really contains three carpels instead of two, as is often suggested, or one as is still more commonly held. Evidently we have here a division of labor in which two carpels form the bulk of the ovary and bear the style-branches while the third usually is reduced to a narrow structure, extending only to the top of the ovary, and containing the bundle which

bears the ovule (pl. V, fig. 122). But in some cases this third carpel is prolonged into a rudimentary style-branch, or even, in rare instances, into a fully developed style-branch, in which case the pistil is obviously composed of three carpels.

Since the structure in *Oryza* so evidently represents three carpels, and since the structure of the other pistils agrees with it, a similar interpretation may well be applied to them.

In *Bromus* the two ventral lobes with the style-branches extending from them represent two carpels, and the large dorsal lobe with its large bundle and ovule represents the third carpel. The same interpretation applies to all pistils of this type. In the *Festuceae* there are all gradations between this kind of a pistil and that of *Oryza*. Thus in this family the third carpel is present in all stages, from the greatly developed dorsal lobe of *Bromus* to the extreme reduction of it in some species of *Festuca*, *Dactylis*, *Poa*, and *Distichlis*.

In the *Hordeae*, an intermediate condition in the reduction of the third carpel is present, in that it is much smaller than in *Bromus*. In *Lolium* the fibrovascular system is intermediate between that of *Bromus* and of *Festuca rubra* since the dorsal bundle branches, but its branches do not unite with the lateral bundles. In *Triticum* and *Secale* the dorsal lobe, or ovule-bearing carpel, is again reduced until it approaches the *Oryza* type.

The pistils of the *Chlorideae* are so like the typical *Oryza* pistil that the same interpretation applies to them.

In the *Aveneae* and *Agrostideae* the same characteristics are found. *Stipa spartea*, however, shows the ventral suture in the form of a very distinct fibrovascular bundle.

The *Paniceae* need special mention, for they typically show the rudiment of the third dorsal style. Since the bundle extending into this is the one bearing the ovule, it is homologous with the third style-branch of *Oryza*.

Andropogon typically, as *Oryza*, has no indication of a third carpel except in the presence of the dorsal, ovule-bearing bundle, but even here one specimen had a very small rudiment of the dorsal style-branch.

In the Maydeae the three carpels are so evident that the tri-carpellary structure is quite obvious. As the pistil develops, two lobes form; one soon shows a notch at the top and elongates into the style with its two branches and two vascular bundles; this represents the two ventral carpels; the other lobe rises independently and bears the ovule and is the dorsal carpel. At this stage the pistil is open like a cup, one side of which bears the style, the other the ovule. Later the two lobes grow together into the pistil, which is then closed.

Eichler (Blüthendiagramme, Gramina, pp. 110, 120, 126) evidently describes the same structure, but he considers the lateral bundles as representing two dorsal carpels. The third carpel he considers to be ventral and usually lacking. He describes the dorsal bundle as the suture between the two dorsal carpels. Hackel (The True Grasses, p. 17) says, "In many pistils (*Briza media*) there is frequently a rudiment of a posterior style (often provided with a stigma) which may be explained as a commissural form like the ligule of *Melica uniflora* Retz." However, the fact that the dorsal bundle in *Oryza* and the Paniceae extends into a rudimentary style-branch (which in *Oryza* may become a perfect one) shows this to be a carpel and not a suture.

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EXPLANATION OF PLATES

In all of the figures, the lettering is as follows: *a*, dorsal lobe; *b*, ventral lobes; *c*, dorsal fibrovascular bundle; *d*, lateral fibrovascular bundle; *e*, ventral suture; *f*, style-branches; *g*, ovule; *h*, lateral branches of dorsal bundle; *i*, dorsal branches of dorsal bundle; *k*, downward branches of dorsal bundle.

PLATE I

1. *Bromus unioloides*, pistil, ventral view. Enlarged about 9 times.

2-12. *Bromus unioloides*, pistil. Cross sections in series; x40. Sections 40 μ thick.

2, Basal section; 3, second section, showing first section of ovule (*g*); 4, sixth section; 5, eleventh section; 6, thirteenth section; 7, fifteenth section, showing the dorsal fibrovascular bundle turning over the top of the ovary; 8, sixteenth section, showing the lateral bundle turning out to the style-branches; 9, eighteenth section, showing the branching of the dorsal bundle; 10, nineteenth section, showing the lateral branches (*h*) of the dorsal bundle extending across to the style-branches and the central part (*i*) extending upward; 11, twentieth section, showing the beginnings of the style-branches (*f*), ventral lobe (*b*), and large dorsal lobe (*a*); 12, twenty-second section—the sections of the dorsal lobe (*a*) continue on up some distance.

PLATE II

13-27. *Bromus unioloides*, pistil. Longitudinal sections 40 μ thick; x16. Series.

13, Second section, showing one lateral bundle (*d*); 14, third section, showing right style-branch; 15, fourth section; 16, fifth section; 17, sixth section; 18, eighth section; 19, ninth section, showing the dorsal bundle and first section of the ovule; 20, tenth section, showing dorsal (*i*) and lateral (*h*) branches of the dorsal bundle (*c*); 21, eleventh section; 22, twelfth section, showing the last of the dorsal bundle; 23, fifteenth section, showing the beginning of the left style-branch, and lateral bundle; 24, sixteenth section; 25, seventeenth section, showing the lateral fibrovascular bundle; 26, eighteenth section; 27, nineteenth section.

28-30. *Bromus unioloides*, very young pistil. Longitudinal sections through middle of ovary; x40.

28, Shows the left style-branch (*f*) and dorsal lobe (*a*); 29, shows the rest of the left style-branch and the dorsal lobe (*a*) with the ovule (*g*); 30, shows the right style-branch.

31. *Festuca rubra*. Young pistil, showing the small dorsal lobe (*a*); x40.

32-37. *Festuca rubra*, pistil. Cross sections in series, 40 μ thick; $\times 40$.

32, basal section with fibrovascular bundle beginning to branch; 33, second section, showing ovule (*g*) and vascular bundles, *d*, *c*, and *k*; 34, third section, showing dorsal bundle turning over the ovary; 35, fourth section, showing the style beginning to separate at the middle; 36, fifth section, showing the tip of the small dorsal lobe (*a*); 37, sixth section, showing the style-branches separated.

38-42. *Festuca rubra*, pistil. Longitudinal sections 40 μ thick; $\times 40$.

38, Second section, left lateral bundle (*d*) and style-branch (*f*); 39, third section; 40, fourth section, ovule (*g*) and dorsal bundle (*c*); 41, fifth section, right style-branch (*f*) and part of the ovule (*g*); 42, sixth section, right style-branch and bundle (*d*).

PLATE III

43. *Distichlis spicata*. Lower part of pistil, median section; $\times 40$.

This shows the ovule (*g*) and the large dorsal fibrovascular bundle (*c*) becoming smaller above the ovule and extending upward through the style.

44-54. *Distichlis spicata*, pistil. Cross sections 40 μ thick; $\times 40$.

44, Section showing the style-branches distinct but close together; 45, fourth section below, style partly fused; the sections are slightly oblique, which causes the two sides not to be alike; 46, fifth section, the beginning of the dorsal bundle (*c*); 47, eighth section; 48, fifteenth section; 49, twenty-eighth section; 50, thirty-fifth section; 51, thirty-sixth section; 52, thirty-seventh section; 53, fortieth section; 54, forty-fourth section.

55. *Distichlis spicata*, pistil. Outline to show general shape of the pistil; $\times 30$.

56-57. *Lolium perenne*, pistils; $\times 30$.

56, Ventral view; 57, dorsal view.

58-62. *Triticum sativum*, pistil. Cross sections 40 μ thick; $\times 40$.

58, Section at top of pistil, showing the style-branches (*f*) and dorsal lobe (*a*); 59, second section; to the right is the tip of the small ventral enlargement; 60, third section; 61, fifth section; 62, seventh section. (The sections continue in the same manner to the base of the pistil.)

63. Diagrammatic cross sections through the ovary to show the four lobes.

PLATE IV

64-72. *Triticum sativum*, pistil. Longitudinal sections, 40 μ thick; $\times 25$.

64, First section; 65, second section; 66, third section; ovule (*g*) attached to dorsal bundle (*c*) near the base of ovary; 67, fourth section; 68, fifth section; 69, sixth section; 70, seventh section; ventral suture (*e*)

extends into an elevation between the ventral lobes; 71, eighth section; 72, ninth section, ventral lobes (*b*).

73-82. *Stipa sparteae*, pistil. Cross sections $40\ \mu$ thick; x40.

73, Section just above forking of the style; 74, second section; 75, third section; 76, fifth section; 77, twelfth section, top of bundle representing the ventral suture (*e*); 78, seventeenth section, dorsal bundle (*c*) turns to the side; 79, nineteenth section; 80, twenty-fifth section; 81, twenty-eighth section; 82, thirtieth section.

83-90. *Stipa sparteae*, pistil. Longitudinal sections $40\ \mu$ thick; x20.

83, Second section; 84, third section; 85, fourth section; 86, fifth section; 87, sixth section; 88, seventh section; 89, eighth section; 90, ninth section. The next section was not drawn.

91. *Oryza sativa*, pistil, x4. This shows two style-branches and a third rudiment.

PLATE V

92. *Oryza sativa*, pistil with three style-branches; x4.

93-96. *Oryza sativa*, pistil. Sections through top of pistil showing the top of rudimentary style-branch with its bundle (*c*) which is dorsal and lower down bears the ovule.

97. *Oryza sativa*, pistil. Longitudinal median section to show the attachment of the ovule in a mature pistil; x16.

98-104. *Oryza sativa*, pistil. Cross sections $40\ \mu$ thick; x40.

98, Section just above forking of the style; 99, section just below forking of the style and showing the extension of the dorsal bundle (*c*).

100-104. Sections completing the series.

105-108. *Oryza sativa*, pistil. Longitudinal sections through middle of pistil to show the vascular bundles and the ovule; x40.

105, Two style-branches, the right with its bundle (*d*); 106, the right bundle (*d*) continued, and dorsal bundle (*c*) present; 107, the three fibrovascular bundles show in part; 108, the same continued.

109-115. *Chaetochloa viridis*, pistil. Longitudinal sections, $20\ \mu$; x40.

109, First section; 110, second section, left style-branch (*f*) and lateral vascular bundle (*d*); 111, third section, left style-branch (*f*), dorsal vascular bundle (*c*); 112, fourth section, base of left style-branch (*f*), dorsal lobe (*a*) and fibrovascular bundle (*c*); 113, fifth section; 114, sixth section, right style-branch (*f*) and fibrovascular bundle (*d*); 115, seventh section, right style-branch (*f*).

116. *Panicum proliferum*, pistil. Median section to show fibrovascular bundles and dorsal lobe (rudimentary style-branch) (*a*).

117. *Panicum scribnerianum*, pistil. Longitudinal median section; x40. Rudimentary style-branch (*a*).
118. *Andropogon sorghum*, pistil. Median longitudinal section; x40. To show the dorsal bundle (*c*) and ovule (*g*) attached near base.
119. Cross section of 118 through the ovary to show the wide dorsal bundle (*c*) and small lateral one (*d*).
120. *Zea mays*, pistil. Longitudinal section of a very young pistil which has not yet closed. The ovule (*g*) is attached to the dorsal lobe (*a*).
121. *Zea mays*, pistil. Longitudinal section of more mature pistil which has closed, leaving only a very narrow opening between the style (*f*) and the dorsal lobe (*a*). The wide branching dorsal fibrovascular bundle (*c*) extends into the ovule and a little above it.
122. Diagrammatic drawing of a grass pistil to illustrate the theory of the arrangement of the three carpels. At each side are the large ventral and lateral carpels with their fibrovascular bundles (*d*) extending into the style-branches. These carpels join at the ventral suture (*e*). On the dorsal side, the narrow wedge-shaped dorsal carpel (*a*) bears the ovule (*g*), and the fibrovascular bundle (*c*) extends nearly to the top of the carpel.

PLATE I

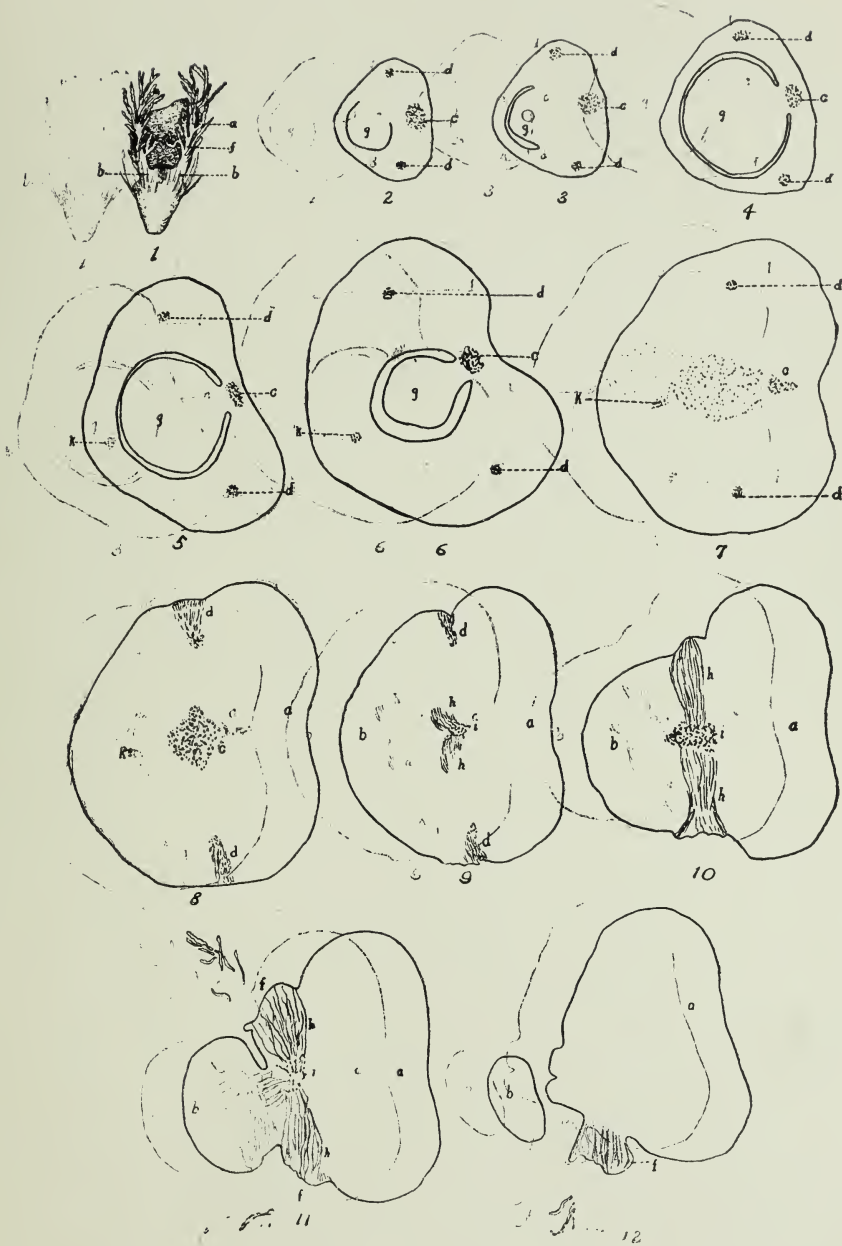


PLATE II

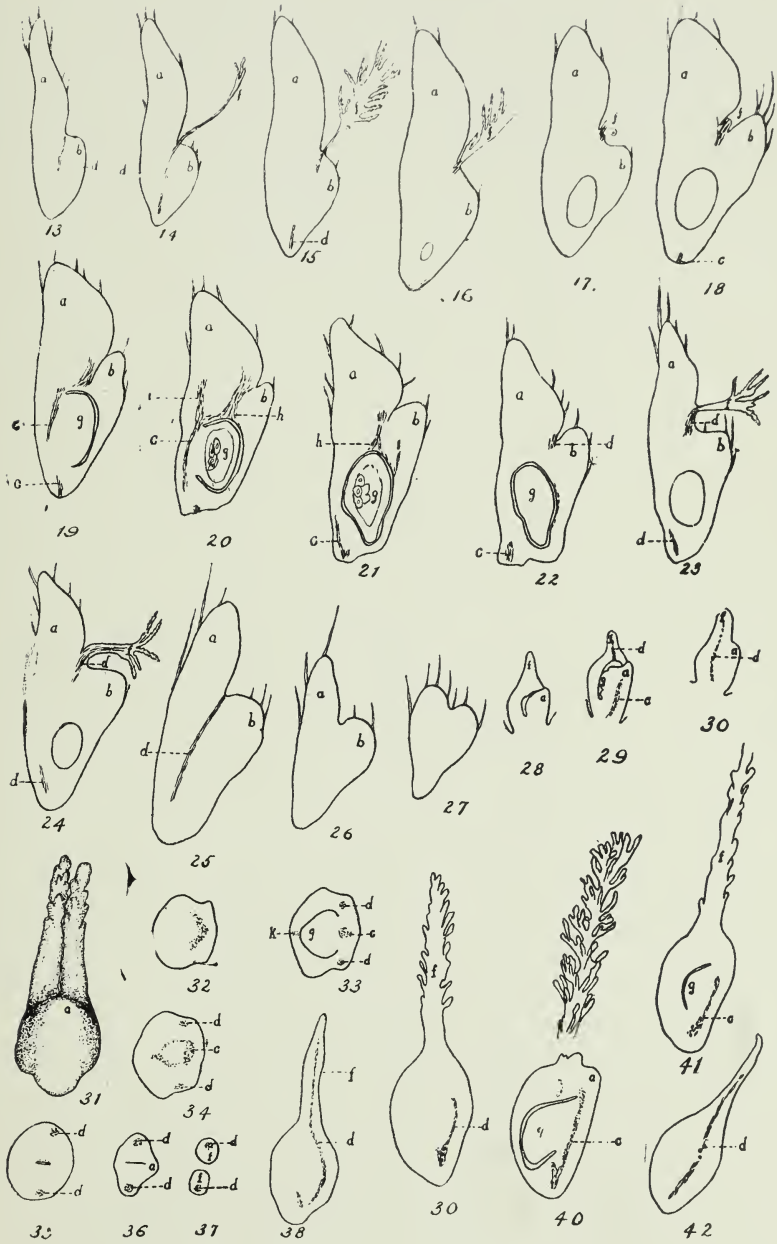
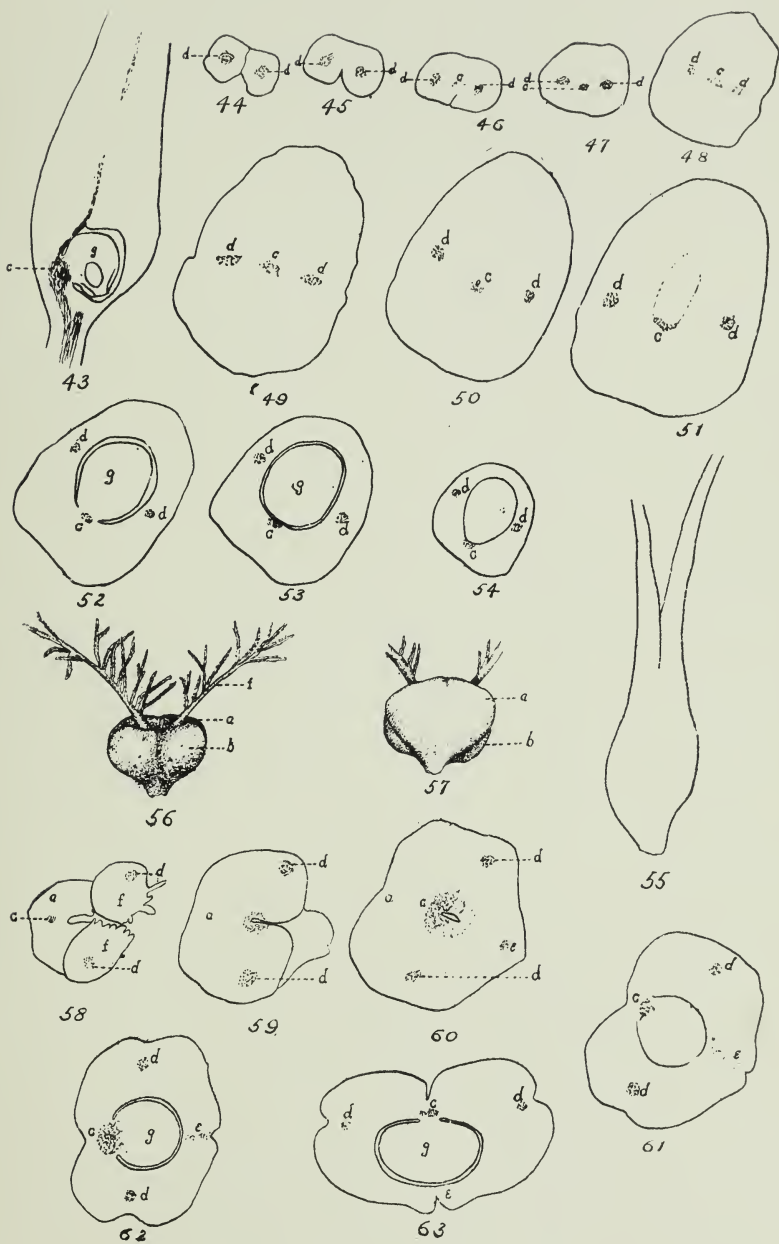
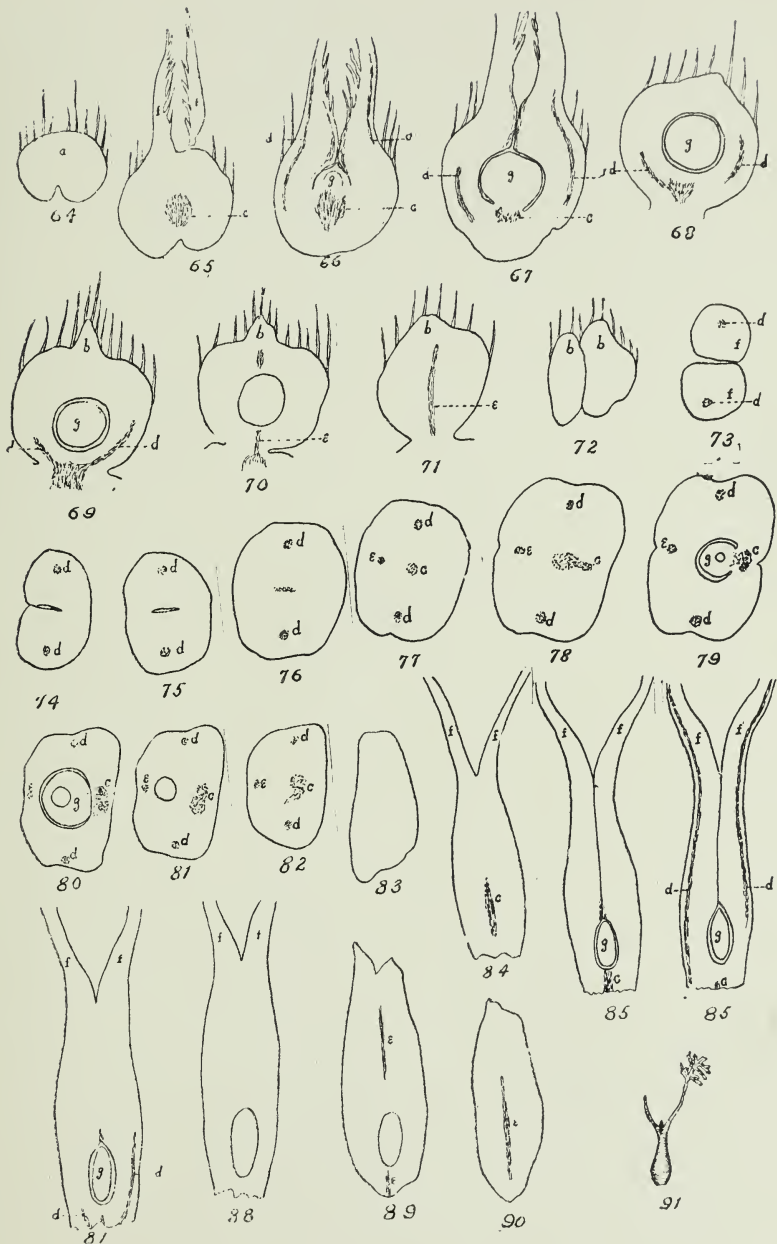


PLATE III



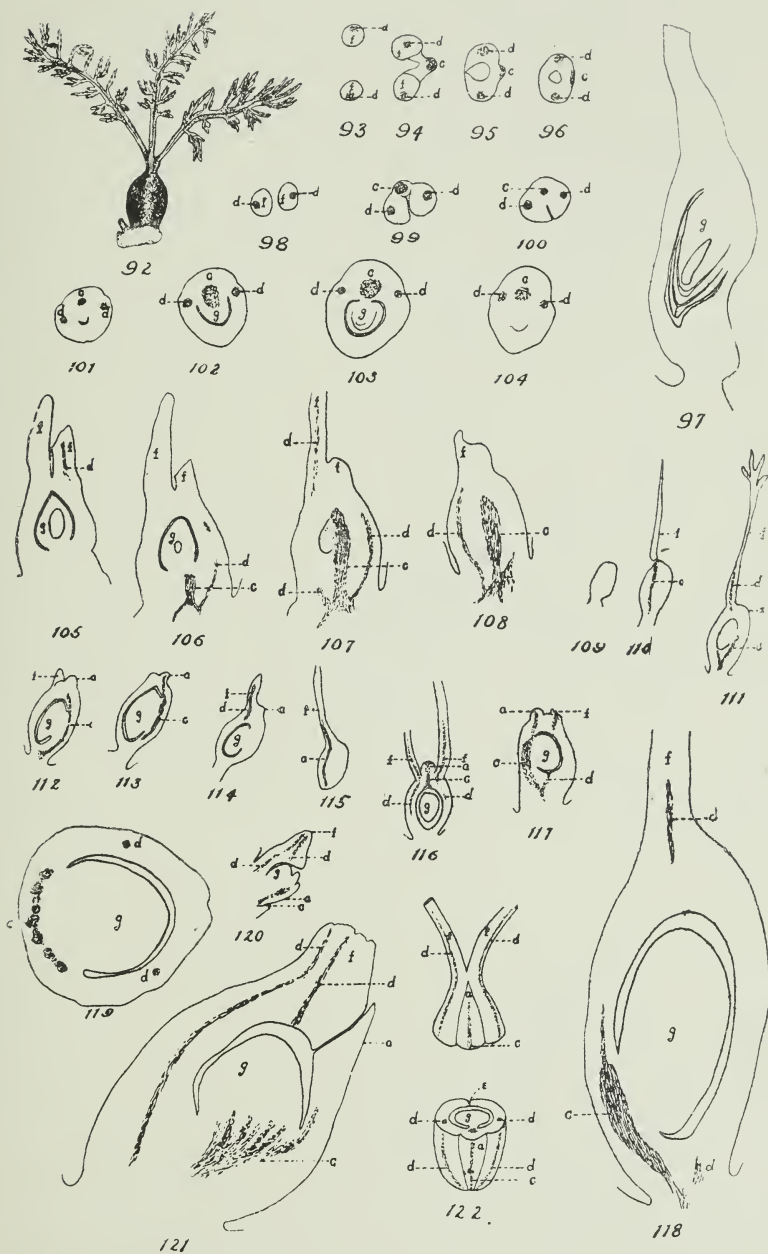
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PLATE IV



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PLATE V



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